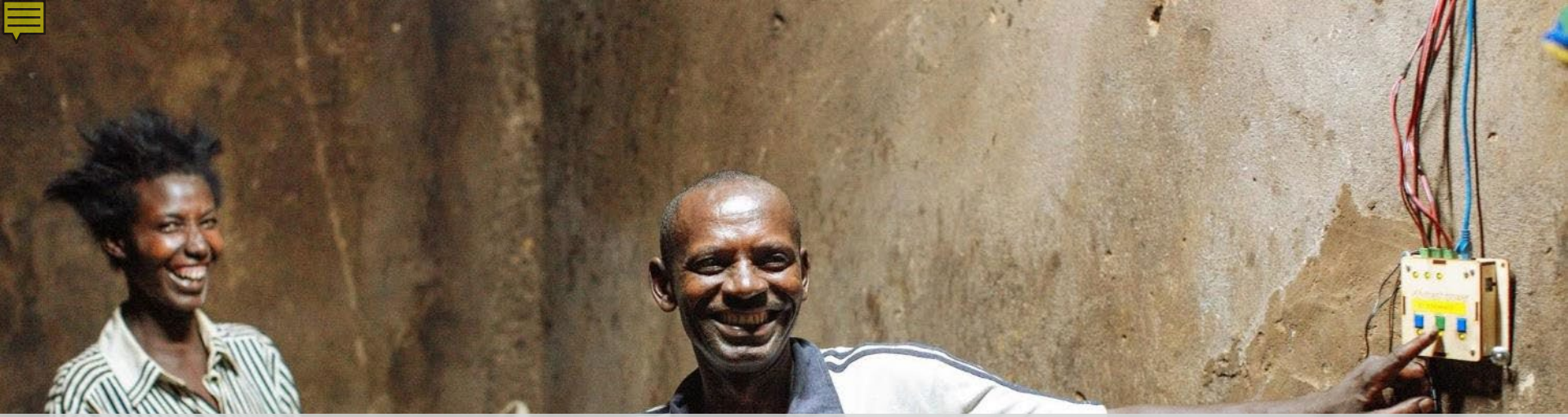


Connecting subsistence communities with DC Microgrids

power

mesh power Rwanda

ENERGY INSTITUTE
COLORADO STATE UNIVERSITY

MeshPower History

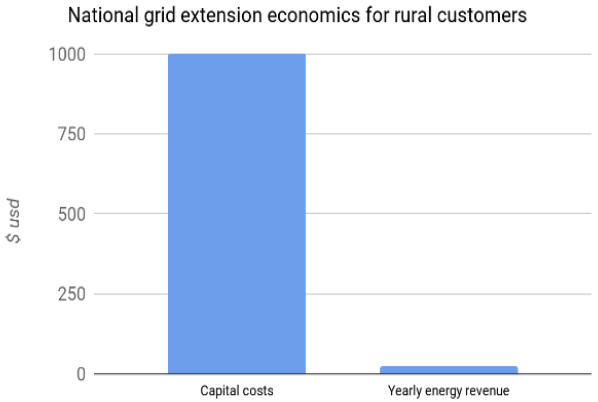
2012	Founded at Imperial College London Develop Tech for low cost DC minigrids
2014	Launched MeshPower Rwanda
2016	Grant co-financed scaleup of DC grids
2017	Start Xpower - Focus on Productive Use in partnership with Colorado State University
Now	70 solar minigrids installed >10,000 Rwandans served with electricity

meshpower Rwanda

The Problem

- Traditional grid extension is focused on high-value customers (industry first).
- Solar-home systems have over 20 years in the market, yet we still see **1 billion**[1] people who lack access to basic electricity.

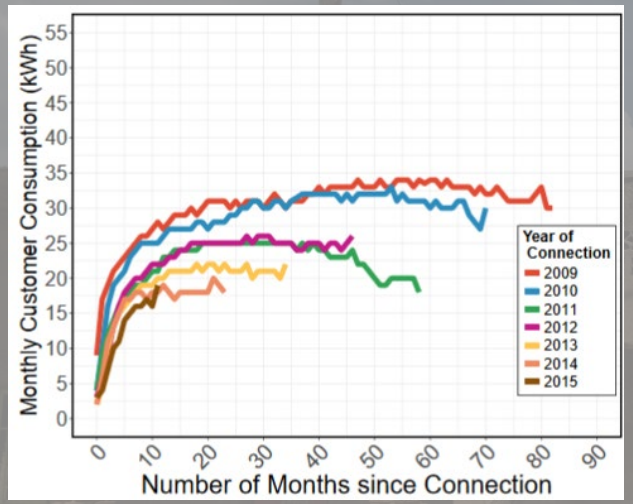
37 of 39 sub-Saharan utilities charge rural tariffs below cost recovery



1) 1bn People living off-grid in Africa & Asia (2016 Bloomberg Solar market report)

“ almost half of consumers are currently using **less than 20 kWh** per month … when a consumer would need to use approximately **130 kWh** per month in order to fund the cost of their own connection “

- Rural Electrification Strategy, Rwanda, 2016



Consumption trends for new rural connections in Kenya

The more rural you go, the higher costs go up, and the lower the energy demand / ability to pay

Jay Taneja, 2018. “If You Build It, Will They Consume? Key Challenges for Universal, Reliable, and Low-Cost Electricity Delivery in Kenya.” CGD Working Paper 491. Washington, DC: Center for Global Development. https://www.cgdev.org/publication/if-you-build-it-will-they-consume-key-challenges-universal-reliable-and-low-cos

Definitions

Electricity for Productive Use - "electricity that enhances income and employment" as opposed to direct consumption by end users.

Productive Use Equipment (PUE) - appliances which use the electricity to enhance a business.

- Ex: embroidery machines at a tailor, welding machines, grain mills, hair salons, egg incubators...
- These are commonly available and use 220V **AC electricity**.

Grid extension often reaches cell towers and industry, but bypasses nearby villages

Current Approaches

- **Grid extension is often too expensive**
- **Minigrids …**
  - Provide higher power levels for productive use
  - Enable community level economic growth & safety (streetlights, markets, business hubs)
  - Current “ABC” approach leaves out typical villages

- **… why not solar home systems?**
  - Low power, low voltage
  - Small scale, individual ownership
  - Unable to run standard productive use equipment

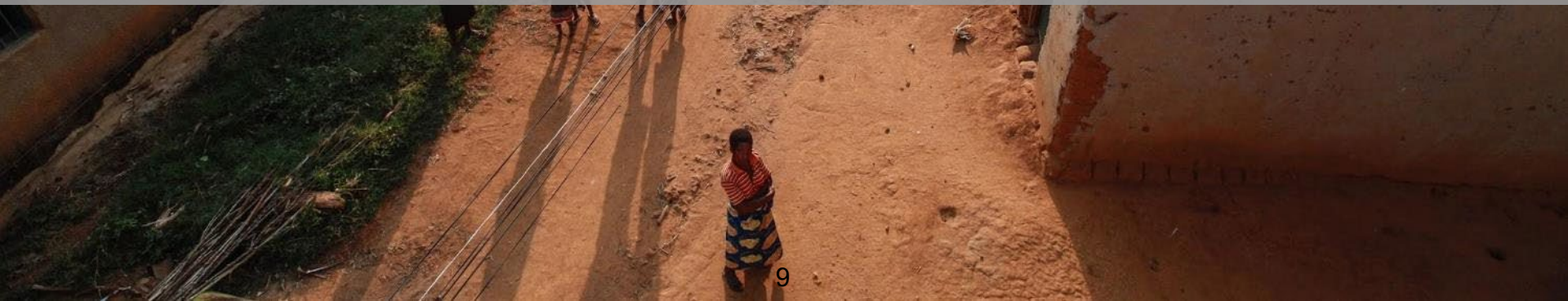
Minigrids: Current Costs

- **“Grid Standard” Minigrids**
  - Single phase, low voltage (220V / 50 Hz)
  - On-premise kWh meter
  - Minimal in-building distribution
  - Central powerhouse

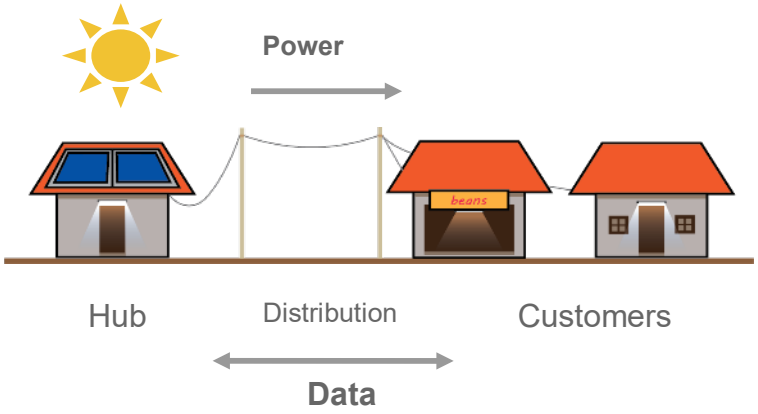
- **Estimated Costs:**
  - ~$980 CapEx / connection
  - ~$7 estimated annual revenue per unit
  - Operating expenses exceed 50% of revenue

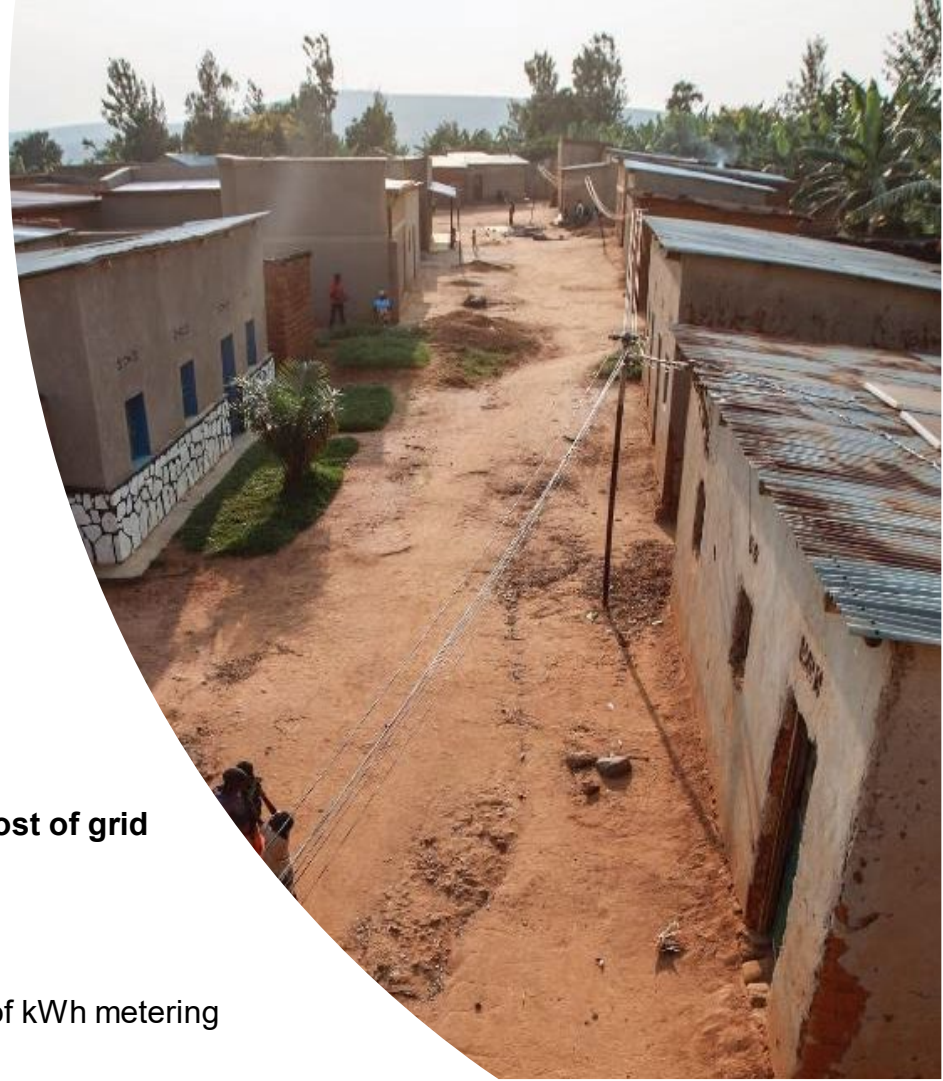
MeshPower Original Solution

Low Cost through Low Voltage DC Distribution



Low Cost / Low Voltage DC



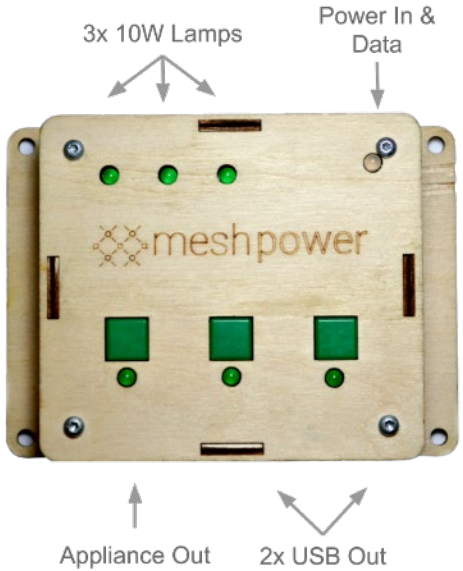


Smart, internet connected solar DC micro-grids ≈ 1/10th the cost of grid

48V DC distribution – lower cost, touch safe, less complex

Electricity as a service – daily service fees instead of kWh metering

Customer Home Unit



The Home Unit

- Customer's portal to basic energy services.
- Basic power distribution & power conditioning.
- Central software control & metering.
- Smart load management and personalized tariffs.

DC Advantage

Right-sized & scaleable:

- Tier 2 Energy access for 50 homes
- Easily upgraded in tandem with growth

Energy-as-a-service

- Customers buy services they want
- Enables customer control and trust

Safe-to-touch Voltage

- Low cost power electronics
- Low cost distribution infrastructure
- Simplified customer protection
- **Lower CAPEX (< $100 / cx)**

MeshPower Experience:

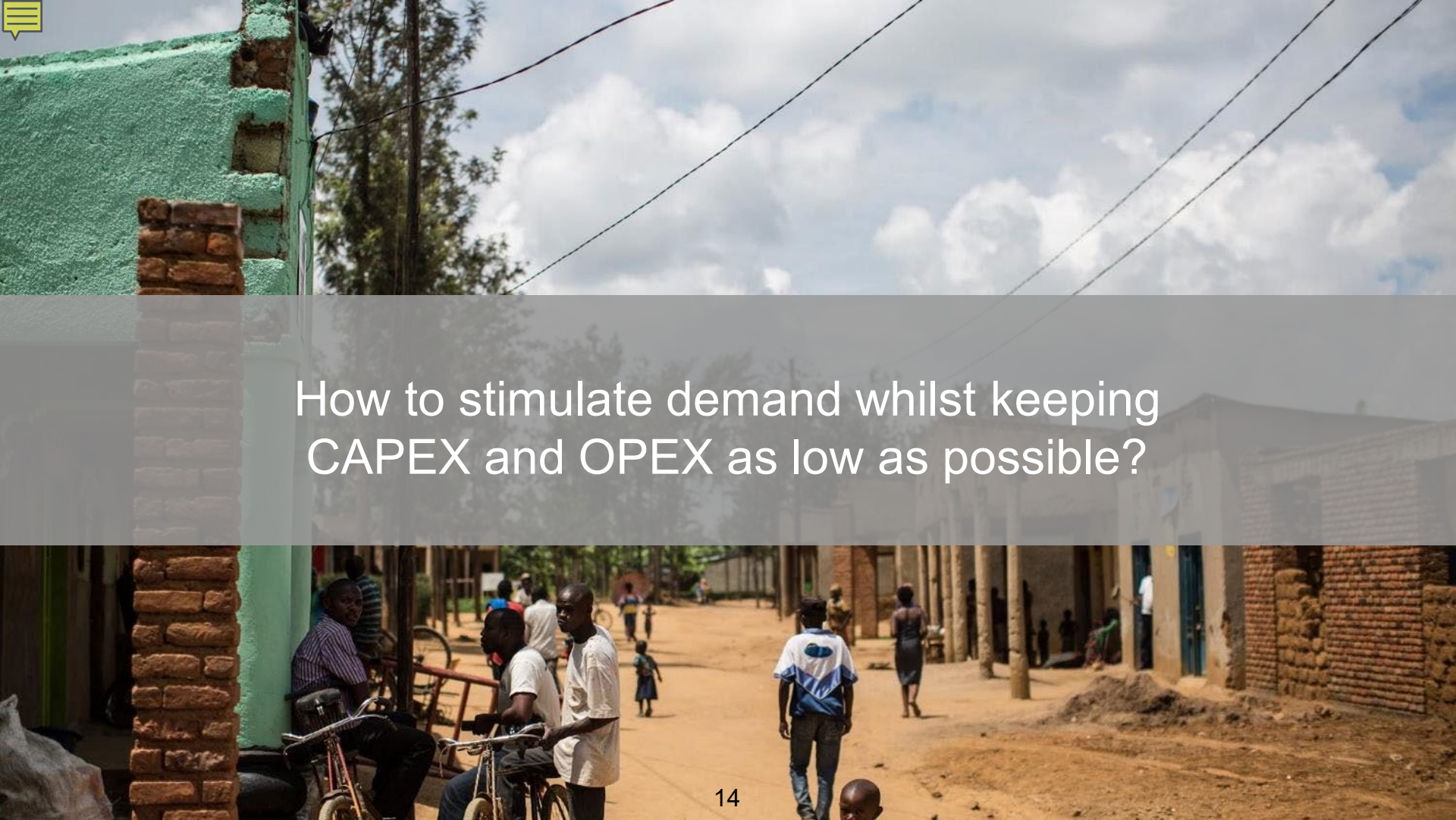
Challenging Economics

Goal

- Prove low cost DC minigrid model viable without anchor loads

Reality:

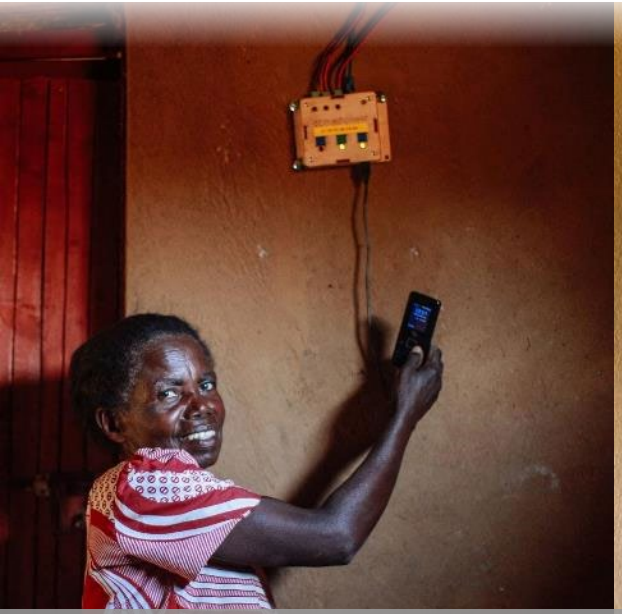
- Low energy demand: 1.8kWh/month
- Low revenue: $2/month/cx
- Low economic growth without intervention
- 6% growth per annum



How to stimulate demand whilst keeping CAPEX and OPEX as low as possible?

Xpower’s hybrid AC/DC approach

A smarter micro grid that brings complete village connectivity at an unrivalled low cost

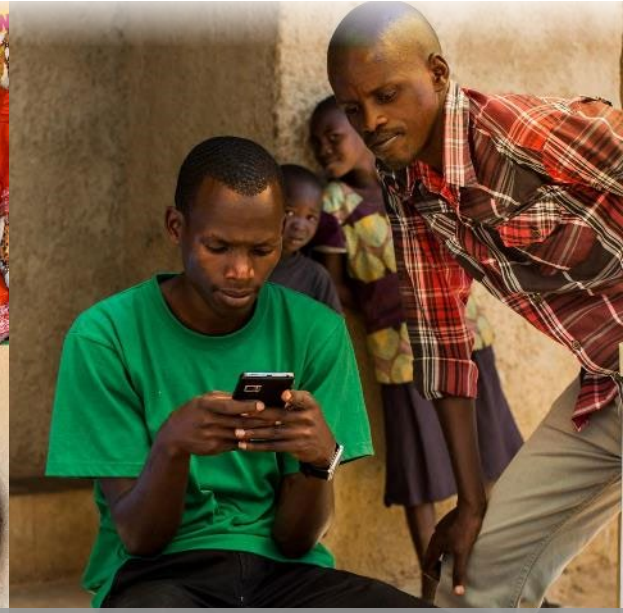


Low cost, 48V DC for households

- Electricity as a service
- Low cost connections
- Quick payback (2-3 years)

High power AC for productive uses

- Target high revenue connections
- Support economic development for future growth



Village-wide internet access for all

- Low cost revenue stream
- Long term resiliency, even with grid expansion

Hybrid (AC/DC) Distribution

Power for Productive Use

Hybrid Approach

Context appropriate grids:

- Pure DC for small villages (<$90 / cx)
- Hybrid AC/DC for large centers (<$300 / cx)
  - Residential DC
  - Commercial $220V_{AC}$

- All connections use smart metering
- Same software backend for customer and load management

Business Model

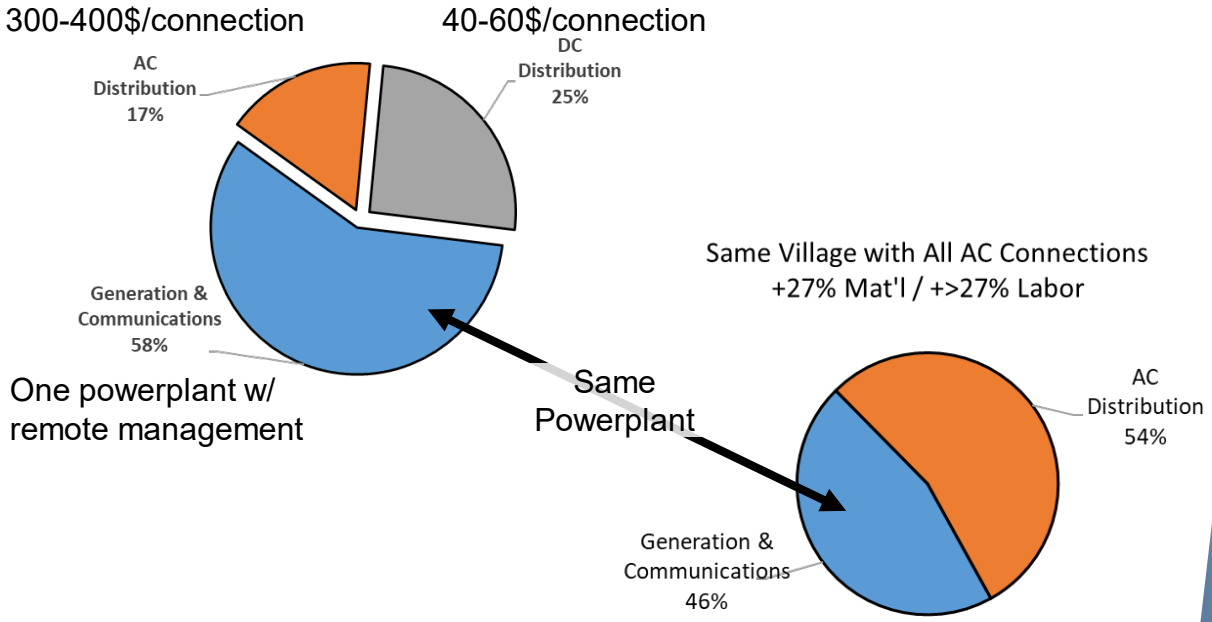
Build, own and operate mini-grids

- PAYG Energy sales:
  - DC on a **service bundle** basis (like prepaid phones)
  - AC on per kWh basis
- WiFi hotspots for internet access
- Appliance financing & demand stimulation

- All automated with topups via mobile money

Current Hybrid Costs

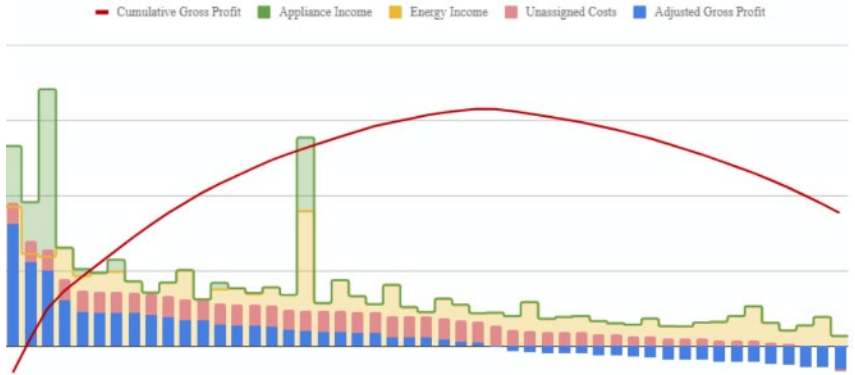
Sample 120 customer grid
10 AC customers / 110 DC customers



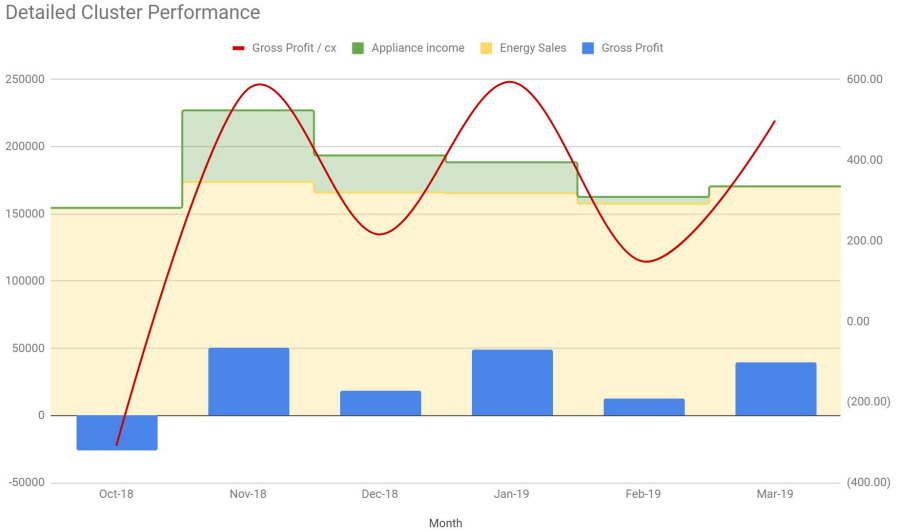
AC example gets equivalent customer equipment as DC example; Market lighting in both examples

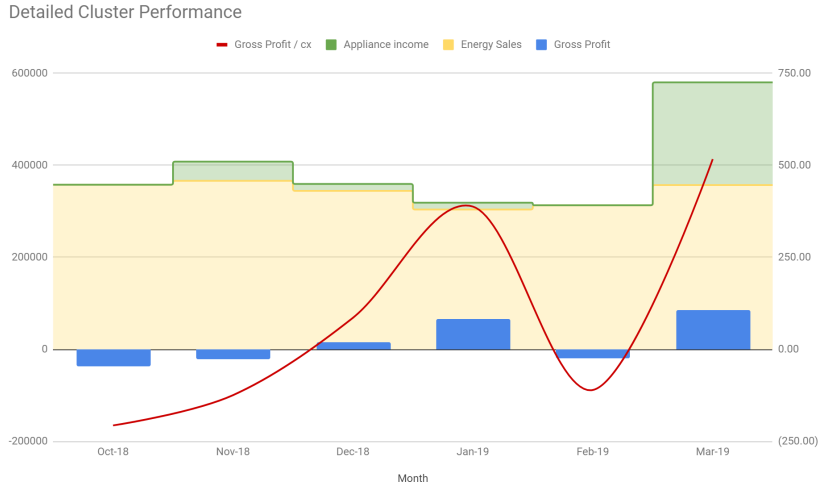
Is it working?

- Working in *subsistence agricultural* villages
- Needs active operational management
  - ½ of all villages are gross profitable
  - Positive trend in operating margin – gross profitability across overall portfolio
- Clusters of villages key to lowering OPEX



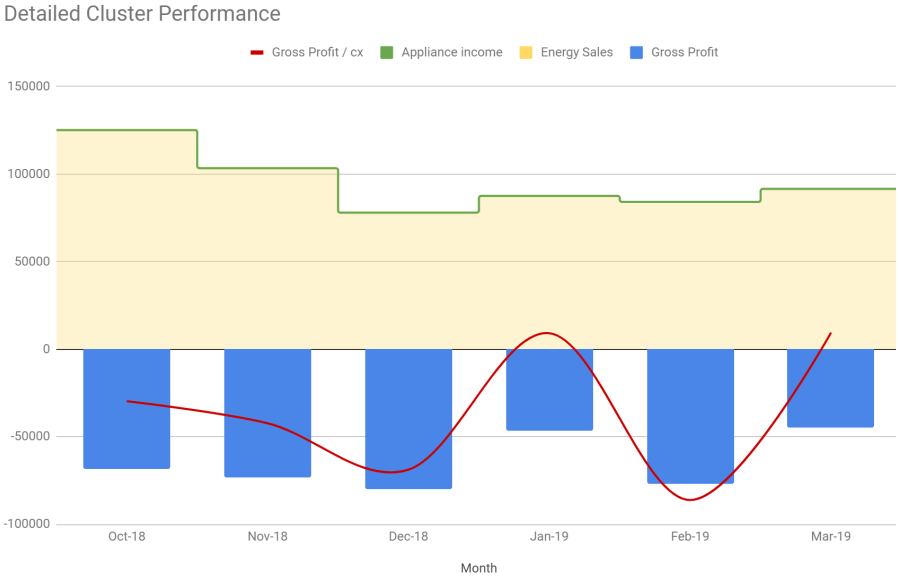
Performance Varies By Cluster

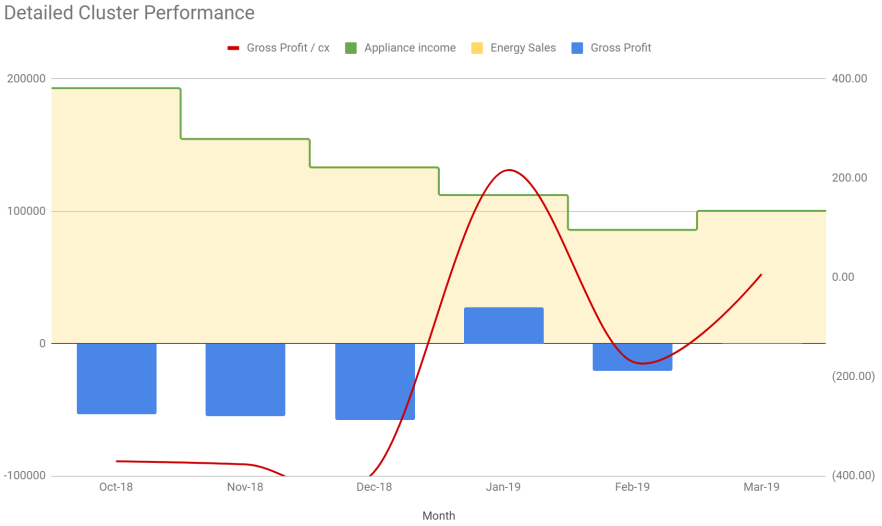




Positive performance typically includes appliance income

Performance Varies By Cluster





Poorest performing villages are where grid is nearby (heavily subsidized electricity) *or* no secondary income from appliances

Productive Use Learnings

Understanding local use-cases essential: In Rwanda, fridges not yet driving consumption

Greatest income benefit not always correlated with energy consumption

Conclusions

- DC power distribution reduces cost of *reaching customers*
- *Touch-safe* DC supports customer-driven electrical extensions within their premise
- Electrification is only one part of economic development in villages
- Need plug standards for DC to develop appliances:
  - Voltage-specific dumb plugs
  - Smart voltage-negotiating connections like USB-C

Xpower today

10,000 consumers, 70 micro-grids, 50 employees

Grid portfolio gross profitable

Thank You

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